Overview of Design for Manufacturing and Assembly (DFMA)

By David K. Porter, P.E.
Crystal Engineering Corp
My Background

- Director of Engineering, Crystal Engineering Corp
- Cal Poly, ME Grad, 1985
- Industries worked:
  - Instrumentation
    - Director/Crystal Engr Corp
  - Telecom Test and Measurement
    - Director/Newport Corp
  - Heavy Duty Automotive
    - Director/ECCO
  - Medical
    - Director/Orbis International
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Overview of Today’s Discussion:
- Definition of DFMA
- Examples
- Design Guidelines

How will this help me in the future?
- Employers look for students with advanced design skills such as knowledge of DFMA and World Class Manufacturing
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- What is DFMA?
- Def’n:  Design for Manual Assembly and/or Design for Manufacture and Assembly
- Why is this important to engineers and why are they the last to learn of it’s benefits?
  - Why show me this now?
  - Why is this discipline the last to be adopted in design engineering
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- Example 1:

  Looks OK, right?
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- Example 1:

After DFMA

What a difference!

Figure 1.12 Reticle assembly—new design. (Courtesy Texas Instruments, Inc.)
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The IMPACT of DFMA on Example 1:

- Less parts to design, document, revise
- Less Bill of Material (BOM) cost, parts to receive, inspect, store, handle
- Less labor and energy to build product
- Gets into the customer’s hands faster
- Less complexity
- Simpler assembly instructions
- Higher quality
- Higher profit margin
- More competitive in the marketplace
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- **Advantages**
  - Quantitative method to assess design
  - Communication tool with other engineering disciplines and other departments (Sales, etc.)
  - Greater role for other groups while still in the “engineering” phase such as Manufacturing
  - Since almost 75% of the product cost is determined in the “engineering” phase, it gives a tool to attack those hidden waste areas before committing to a design

- **Fact:** Fasteners typically account for 5% of BOM cost, yet contribute to 70% of the labor cost!
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- Example 2

Motor Drive

Proposed Design

Final Design
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- Example 3

Power Saw Project
(Original Test Case)

Facts:
- 41 vs. 29 Parts
- 6.37 vs. 2.58 min
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- History:
  - Formal methods began in late 70’s
  - Empirical studies followed for handling parts
  - System for estimating assembly times followed in early 80’s
  - Geoffrey Boothroyd pioneered system while at U of Mass on Power Saw project (just shown)
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- Each part has a handling and insertion time penalty
  - The more complex the part the larger the time penalty
  - The more precise the alignment the heavier the penalty

![Diagram showing various parts with their symmetries]

- Data compiled by time studies of such manufacturers as Motorola
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- Chart established for Handling
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- ...and Insertion
### DFMA – Quick Analysis

**Example A**

<table>
<thead>
<tr>
<th>Item Name: Part Sub or PCB Assembly or Operation</th>
<th>Quantity</th>
<th>Handling Code</th>
<th>Handling Time per Item (sec)</th>
<th>Insertion Code</th>
<th>Insertion Time per Item (sec)</th>
<th>Unit Operation Time (sec)</th>
<th>Unit Operation Cost ($)</th>
<th>Unit Material Cost ($)</th>
<th>Unit Part Cost ($)</th>
<th>Extended Part Cost ($)</th>
<th>Extended Operation Time (min)</th>
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</thead>
<tbody>
<tr>
<td>Box on Worksurface</td>
<td>1</td>
<td>02</td>
<td>1.8</td>
<td>60</td>
<td>5.5</td>
<td>7.3</td>
<td>0.0304</td>
<td>0.0304</td>
<td>0.03</td>
<td>0.12</td>
<td></td>
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<tr>
<td>Place assy</td>
<td>1</td>
<td>02</td>
<td>1.8</td>
<td>00</td>
<td>1.5</td>
<td>3.3</td>
<td>0.0138</td>
<td>0.0138</td>
<td>0.01</td>
<td>0.06</td>
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<tr>
<td>Screw down Assy</td>
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<td>01</td>
<td>1.5</td>
<td>85</td>
<td>10.0</td>
<td>11.5</td>
<td>0.0479</td>
<td>0.0479</td>
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<td>0.77</td>
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<tr>
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<td>00</td>
<td>1.5</td>
<td>2.6</td>
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<td>0.0110</td>
<td>0.01</td>
<td>0.04</td>
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**Total** $0.25 $0.99

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**Example B**

<table>
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<th>Quantity</th>
<th>Handling Code</th>
<th>Time per Item (sec)</th>
<th>Insertion Code</th>
<th>Insertion Time per Item (sec)</th>
<th>Unit Operation Time (sec)</th>
<th>Unit Operation Cost ($)</th>
<th>Unit Material Cost ($)</th>
<th>Unit Part Cost ($)</th>
<th>Extended Part Cost ($)</th>
<th>Extended Operation Time (min)</th>
</tr>
</thead>
<tbody>
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<td>01</td>
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<td>60</td>
<td>5.5</td>
<td>7.0</td>
<td>0.0292</td>
<td>0.0292</td>
<td>0.03</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Place assy</td>
<td>1</td>
<td>02</td>
<td>1.8</td>
<td>60</td>
<td>5.5</td>
<td>7.3</td>
<td>0.0304</td>
<td>0.0304</td>
<td>0.03</td>
<td>0.13</td>
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<td>Screw down Assy</td>
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<td>1.5</td>
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<td>0.0138</td>
<td>0.01</td>
<td>0.06</td>
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**Total** $0.20 $0.81

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- DFMA.com Software
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- Example 4

Figure 3.35  Controller assembly.

Figure 3.37  Conceptual redesign of the controller assembly.
The Waste of Complexity:

- The goal is to achieve simple solutions in place of complex ones.
- Complex solutions tend to produce more waste and are harder for people to manage.
- Waste can take the form of time, energy, labor, defective production, etc.

In our case, replace “solution” with “design”
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- Who is using it?....the same people who first adopted Solid Modeling......
  - Boeing / Lockheed Martin / Northrop Grumman / McDonnell Douglas
  - Hewlett-Packard
  - Ford / GM / Chrysler
  - Texas Instruments
  - Toy manufacturers
  - Your future employer.....
  - The list goes on and on.......
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- Examples......
  - Longbow Apache Helicopter
    - Pilot Instrument Panel:
      Fabrication/Assembly/Installation time reduced from 697 hours to 181!
    - Co-Pilot Instrument Panel:
    - Part count 12, down from 87
  - C-17:
    - 9 million components, 1 million man hrs to build
    - DFMA on landing gear bulk head went from 72 detail parts and 1,720 fasteners to 2 parts and 35 fasteners! (McDonnell Douglas)
      (Examples from DFMA.com)
DFMA – Design Guidelines

- Design for top down assembly
- Make parts self locating
- Try to design parts with symmetry
- If symmetry is not possible then make it obvious that the part needs a specific orientation
DFMA – Design Guidelines

- Prevent stacked parts from getting stuck together or tangled using features

- Avoid parts that are difficult to handle, i.e. too small, sharp, fragile, etc.

- Avoid parts that only connect. Try and bring the other parts together to eliminate the connection

- Avoid adjustments. In general, adjustments compensate for poor design
DFMA - Guidelines

Figure 3.39  Rearrangement of connected items to improve assembly efficiency and reduce costs.

Figure 3.40  Design concept to provide easier access during assembly.

Figure 3.41  Design to avoid adjustment during assembly.

Figure 3.43  Showing how overconstraint leads to redundancy of parts.
DFMA - Guidelines
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Your Cal Poly Education will:

- Teach you to use powerful tools such as SolidWorks
  - This tool will allow you to design using the DFMA philosophy...........parts reduction
  - Make sure you use the tool to the fullest!

- Remember...it is very difficult to make things simple.......
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- Good websites for further info on DFMA and World Class Manufacturing:
  - npd-solutions.com (best website by far!)
  - DFMA.com (Boothroyd and Dewhurst products)
  - Superfactory.com

- Sources of information used:
  - Larry Stauffer, Ph.D, P.E., University of Idaho – TechHelp